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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 472

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. PROFESSIONAL PAPER October 30, 1916

IMPROVED APPARATUS FOR DETERMINING THE TEST WEIGHT OF GRAIN, WITH A STANDARD METHOD OF MAKING THE TEST.

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INTRODUCTION.

The improved testing apparatus for obtaining the weight per bushel described in this bulletin was designed to reduce to a minimum the personal error in making the test and to standardize the method of determining the test weight of grain.

The importance of "weight per bushel" is well known to the grain trade. It is a recognized fact that, other things being equal, the heavier a sample of grain, the better it is; and consequently we find grain dealers, grain judges, and grain inspectors referring to and relying on this test almost more than on any other. The grain dealers know that a heavy, plump sample has the highest commercial value or will change hands most readily at a given price, and the miller knows that the heavy sample will produce the most flour.

Judges at shows and competitions, especially when the competition is close, often select the best samples from among the competing lots of grain and then award the prizes according to the weight per bushel.

Investigators endeavor, by comparing different varieties of grain tested during a series of years, to determine which varieties in a given district produce on the whole the heaviest grain, in order to

meet the two important requirements of high yield per acre and a high commercial grade when the grain gets into commerce.

In order to indicate the comparative values of different lots of grain, the grain-inspection departments of various States and grain exchanges have promulgated and adopted grain grades and rules in which the test weight is one of the principal factors.

When grain is sold by grade, as most of that which gets into commerce is at one time or another before it is finally consumed, the price is almost invariably found to be parallel with the grade; that is, the highest grades command the highest prices, while the lowest grades command the lowest prices.

In these grades a minimum test weight per bushel is usually specified for at least the higher grades of wheat, oats, barley, rye, flaxseed, and buckwheat.

These conditions illustrate the importance of the weight per bushel test for grain. Mere haphazard testing, however, is of little use and only leads to confusion and disputes among the interested parties. It is needless to state to one familiar with grain testing that in order to obtain uniform results the tests must be made in a uniform manner. It is surprising how a slight variation in the method will cause a difference in the result, yet we find that there are many methods in everyday use, when the country as a whole is considered.

VARIATION IN METHODS OF MAKING THE TEST WEIGHT PER BUSHEL OF GRAIN.

Some of the more common methods of testing the weight per bushel are pulling the kettle through the grain until it is full; sinking the kettle part way into the grain and filling it by pulling the grain over the edge by hand, sometimes filling it by a few handfuls and sometimes by several small handfuls; filling the kettle from a bag, pan, or funnel, the bag, pan, or funnel in some cases being held at a height almost even with the top of the test kettle and at other times raised to a height of 10 or 12 inches above the kettle; pouring the grain into the test kettle, sometimes in a thin, small stream, and at other times, in a large, heavy stream; and striking the excess grain off from the kettle with the scalebeam, a sawed-off piece of broomstick, a pencil, or other implement, and occasionally tapping or jarring the kettle before the surplus is struck off or pressing the grain into the kettle before it is struck off. Each of the methods described will give a result all its own. If a given lot of grain were to be tested according to each of the methods mentioned, some of the results would no doubt be similar, if not exactly alike, while others would vary considerably. With such grains as oats, barley, and rough rice, it is a very simple matter to obtain results which vary as much as 1½ pounds

or more per bushel by making the test according to different methods, as is shown in some of the following tables and figures.

Table I shows the variations in test weight per bushel obtained by filling the test kettle by different methods. These tests were all made by the same person, and an attempt was made to make them in exactly the same manner as they had been observed to have been made by various investigators, grain dealers, and grain inspectors while testing grain in commercial work. The tests, with the exception of those made with the aid of a hopper, were all made with an ordinary quart tester and with commercial oats in a railroad car, and so far as possible with the same portion of the grain in the car. The tests made with the hopper were made in the laboratory on samples of the same oats which had been tested in the car by the other methods described.

TABLE I.—*Test weight per bushel of oats, showing the variation in the results obtained by filling the test kettle by different methods.*

Method of filling the test kettle.	Weight per bushel (pounds).							
	Individual tests.					Minimum.	Maximum.	Average.
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.			
Test kettle filled from a bag held 2 to 3 inches above the kettle	37	37.5	37.5	38.25	37	37	38.25	37.45
Test kettle sunk into the grain and grain pulled into the kettle by hand:								
(1) By one motion of both hands	36.5	36.5	36.5	36.5	36.25	36.25	36.5	36.45
(2) By 9 to 11 motions of both hands	37	37	37	36.75	37	36.75	37	36.95
Test kettle filled by dipping it into the grain	38.75	39.25	39	39.5	39.5	38.75	39.5	39.20
Test kettle filled by pulling it through the grain by about a 2-foot sweep:								
(1) Through loose, worked-over grain	38	38.25	38.25	38.25	39.5	38	39 5	38.45
(2) Through the packed surface of the grain in a car before the grain had been worked over	39.75	40.75	39.5	39	39.75	39	40.75	39.75
Test kettle filled from a hopper having an outlet opening 1¼ inches in diameter held 2 inches above the kettle and weighings made on the special beam described in this bulletin.	37.2	37.2	37.3	37.2	37.2	37.2	37.3	37.22

Table I shows that the different methods of filling the test kettle resulted in a considerable variation in the test weights that were obtained. The greatest variation in the results of the five tests of any one method was 1.75 pounds; the greatest variation in the averages for the different methods was 3.3 pounds; while the greatest difference in the results of all the tests was as much as 4.5 pounds. The results obtained by the hopper method varied but one-tenth of a pound per bushel in the five tests. Had the tests been made by some other person or by different persons, or had the grain been in different conditions of dryness or cleanness, the results would, no doubt, have varied somewhat from those given in the table. The influence

of moisture content on the test weight of grain is illustrated in figure 1, which shows how a large sample of corn, which was allowed to dry

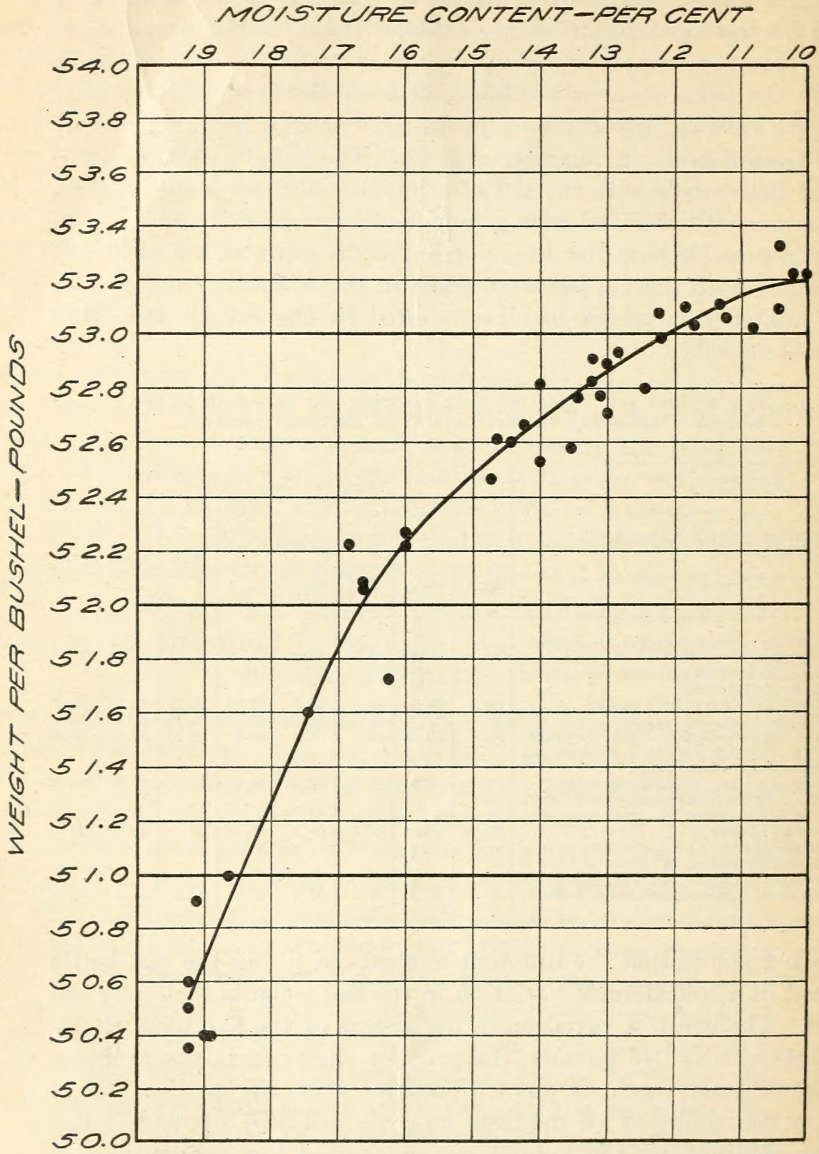

FIG. 1.—Diagram showing how the test weight per bushel of corn increases as the moisture content of the corn is reduced by natural drying.

naturally, increased nearly 3 pounds in test weight per bushel as the corn dried down from a moisture content of slightly over 19 per cent to a moisture content of 10 per cent.

PROPER METHOD OF FILLING THE TEST KETTLE.

Table II gives the results obtained by filling the test kettle from a hopper and shows the influence on the test weight per bushel of (*a*) the height of the fall, or the distance of the hopper opening above the test kettle, and (*b*) the size of the grain stream, or the diameter of the hopper outlet opening. These data represent the average results of 10 tests under each condition specified in the tests with the special apparatus described in this bulletin. In making these tests three hoppers were used, having outlet openings 1, 1¼, and 1½ inches in diameter, respectively. A large sample of each of the grains shown in the table was split up into nine equal portions with a sampling device[1] and mixed until each sample showed the same test weight under the same conditions.

TABLE II.—*Test weight per bushel of different grains, showing the influence of the height of fall and of the size of grain stream in filling the test kettle.*

[Average results of 10 tests under each condition described.]

Grain and diameter of hopper opening.	Test weight per bushel (in pounds) when the distance of the hopper opening above the kettle was—			Grain and diameter of hopper opening.	Test weight per bushel (in pounds) when the distance of the hopper opening above the kettle was—		
	2 inches.	3 inches.	4 inches.		2 inches.	3 inches.	4 inches.
Flaxseed:				Emmer:			
1 inch	52.34	52.35	52.34	1 inch	28.04	28.54	28.65
1¼ inches	52.34	52.35	52.34	1¼ inches	27.85	28.25	28.43
1½ inches	52.35	52.36	52.34	1½ inches	27.62	28.05	28.26
Milo:				Corn:			
1 inch	59.30	59.39	59.55	1 inch	54.99	55.50	55.71
1¼ inches	59.24	59.31	59.46	1¼ inches	54.78	55.28	55.44
1½ inches	59.22	59.26	59.36	1½ inches	54.67	55.08	55.29
Wheat:				Barley:			
1 inch	61.20	61.32	61.45	1 inch	47.08	47.35	47.78
1¼ inches	61.14	61.25	61.34	1¼ inches	46.87	47.10	47.46
1½ inches	61.08	61.16	61.20	1½ inches	46.66	46.86	47.23
Rye:				Oats:			
1 inch	53.98	54.12	54.20	1 inch	37.31	37.65	38.03
1¼ inches	53.88	54.00	54.05	1¼ inches	37.05	37.25	37.67
1½ inches	53.81	53.92	53.98	1½ inches	36.81	37.01	37.35
Rice, rough:							
1 inch	43.33	43.43	43.61				
1¼ inches	43.15	43.25	43.40				
1½ inches	42.85	42.95	43.24				

It will be observed that neither the height of fall nor the diameter of the hopper outlet opening affects the test weight of flax to any appreciable extent, but both factors have a decided and direct influence on the test weight of the other grains, the effect being more noticeable with the large or loose-structured grains than with the

[1] The sampling device used in these experiments is explained in U. S. Department of Agriculture Bulletin No. 287, by E. G. Boerner, entitled "A device for sampling grain, seeds, and other material," issued Sept. 14, 1915. This device has been covered by a public-service patent.

smaller grains of close, compact structure. The data in Table II are illustrated in figures 2 and 3.

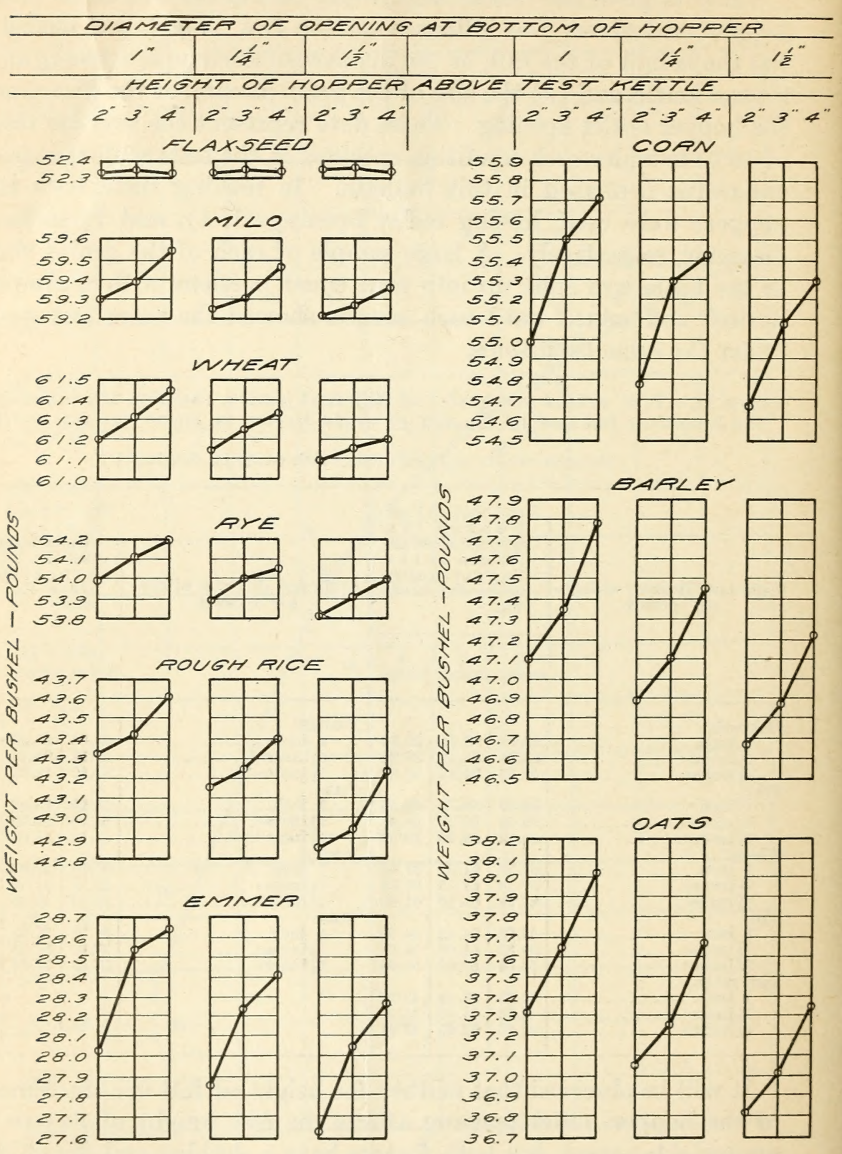

FIG. 2.—Diagram illustrating the influence on the test weight per bushel of allowing grain to fall from varying heights in filling the test kettle, the diameter of the grain stream remaining the same.

Figure 2 shows that the test weights grow heavier as the height from which the grain falls into the test kettle is increased. This result is probably due to the heavier pounding effect on the grain

in the test kettle caused by the increased momentum which the grain receives from a greater distance of fall.

The experiments demonstrated that 2 inches is the shortest distance from the top of the test kettle to the hopper opening which is

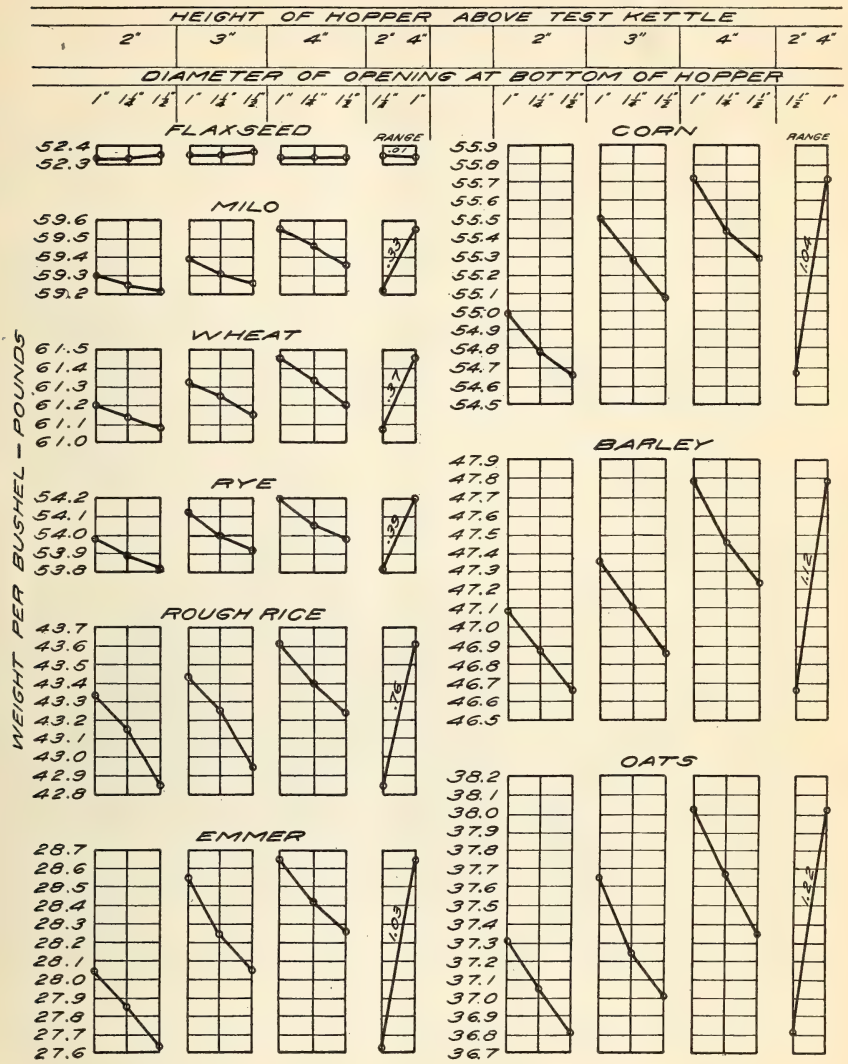

FIG. 3.—Diagram illustrating the influence on the test weight per bushel of filling the test kettle by different-sized grain streams, the height of fall remaining the same.

practicable for all grains, and, as this corresponds with the best trade practices and with the recommendations of the Chief Grain Inspectors' National Association, this has been fixed as the proper height above the kettle from which grain should fall in making the test.

The rule which the Chief Grain Inspectors' National Association has recommended for determining the test weight per bushel of grain reads as follows:

> Place the kettle where it can not be jarred or shaken. From scoop, bag, or pan held 2 inches from the top of the test kettle, pour into the middle of the kettle at a moderate speed until running over. Strike off in a zigzag manner with the edge of the beam held horizontally.

It will be seen from figure 3 that with the exception of the tests with flax, the test weight shows heavier as the size of the grain stream or diameter of the opening at the bottom of the hopper is decreased. This result is probably due to the longer pounding effect of the grain when falling in a thin stream.

While the figures show the results for all grains tested by the use of the 1-inch opening in the hopper, the experiments demonstrated that this opening was too small for practical work with such grains as oats, barley, corn, rough rice, and emmer, since these grains run through the 1-inch opening very slowly and frequently clog in the opening and have to be started again with a pencil or by some other means. An opening $1\frac{1}{4}$ inches in diameter was found to be the smallest opening satisfactory for all grains, and as this corresponds very closely with the best trade practices it has been fixed as being the proper diameter for the hopper opening in making tests of weight per bushel of grain.

From what has been stated, it can readily be seen that the test weight per bushel is of vital importance in the buying and selling of grain. It has also been pointed out that, considering the country as a whole, there are many methods of making the test and that serious differences in results occur when different methods are employed. It is generally conceded that standard grades for grain with definite specifications are desirable, and it should be equally apparent that the methods of testing for grade should be put on a standard basis, for unless the same methods of making the tests at the country points and the terminal markets or at different markets are used, widely varying results are sure to be obtained and dissatisfaction will result. To standardize the test, the first essential is the elimination, so far as possible, of the personal error, and to accomplish this result an apparatus having a hopper with a definite-sized opening or outlet at its base, held in place so that this opening will always be at a given distance above the top of the test kettle, appears to be the most feasible from a practical viewpoint, and the apparatus herein described was devised with that feature in view.

DESCRIPTION OF THE DEVICE.

The apparatus (figs. 4 and 5) is in two main parts: (1) The stand, with hopper and overflow pan, and (2) the test kettle, with a special beam. The base of the stand is made up of two layers of wood held together with screws. Each layer is 1½ inches thick, the

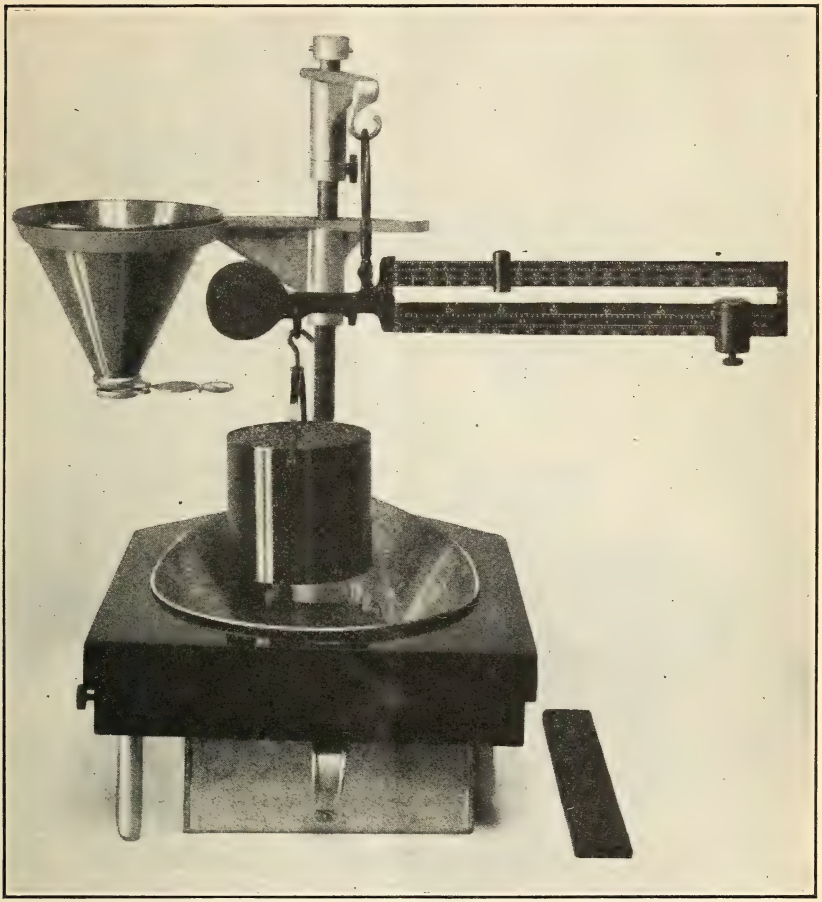

FIG. 4.—Front view of the special apparatus for testing the weight per bushel, showing the hopper swung to the left and a filled test kettle balancing the special beam.

upper layer projecting one-fourth inch over the lower layer around the edges, so that the base can be conveniently fastened into a table top if desired. In the forward part of the base is contained a circular opening with beveled edges, of the shape and size shown in figures 6 and 7. A grate made of four metal bars fastened into the lower layer of the base extends across the opening in the base, as

shown in figure 8. A circular metal disk, or plate, upon which the test kettle rests when in place, is clamped on the upper side of the grating in such a position that the center of the plate coincides with the center of the opening in the base. Two metal guide pins, about 3 inches apart, are fastened to the edge of the plate and then extended upward about half an inch higher than the surface of the

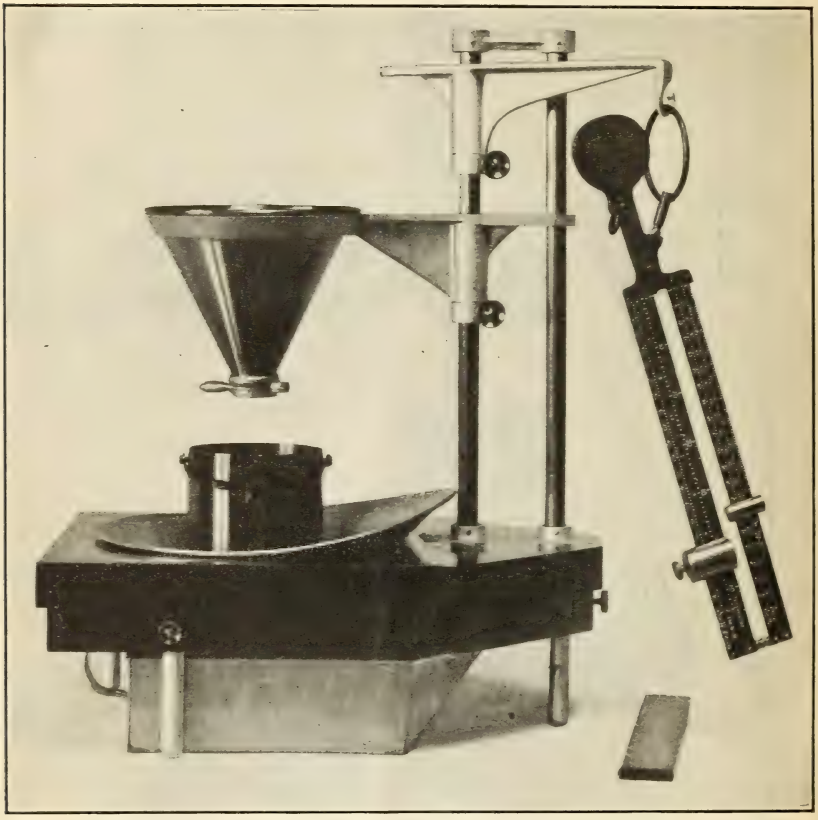

FIG. 5.—Side view of the special apparatus for testing the weight per bushel, showing the beam swung to the right and the hopper and test kettle in place ready for filling the kettle.

plate. These guide pins are placed here to center the quart test kettle when it is in place on the plate. The two guide pins are connected by a strip of metal of the size and shape illustrated in figures 7 and 8. This strip of metal is free swinging, and when swung over on the plate forms a guide for centering the pint test kettle.

Fitted into metal sockets sunk into the after part of the base are two tubular metal posts 19 inches long and connected with a casting

at their upper ends. Fitted to the forward or main post are two free-swinging metal brackets or arms, the lower one of which termi-

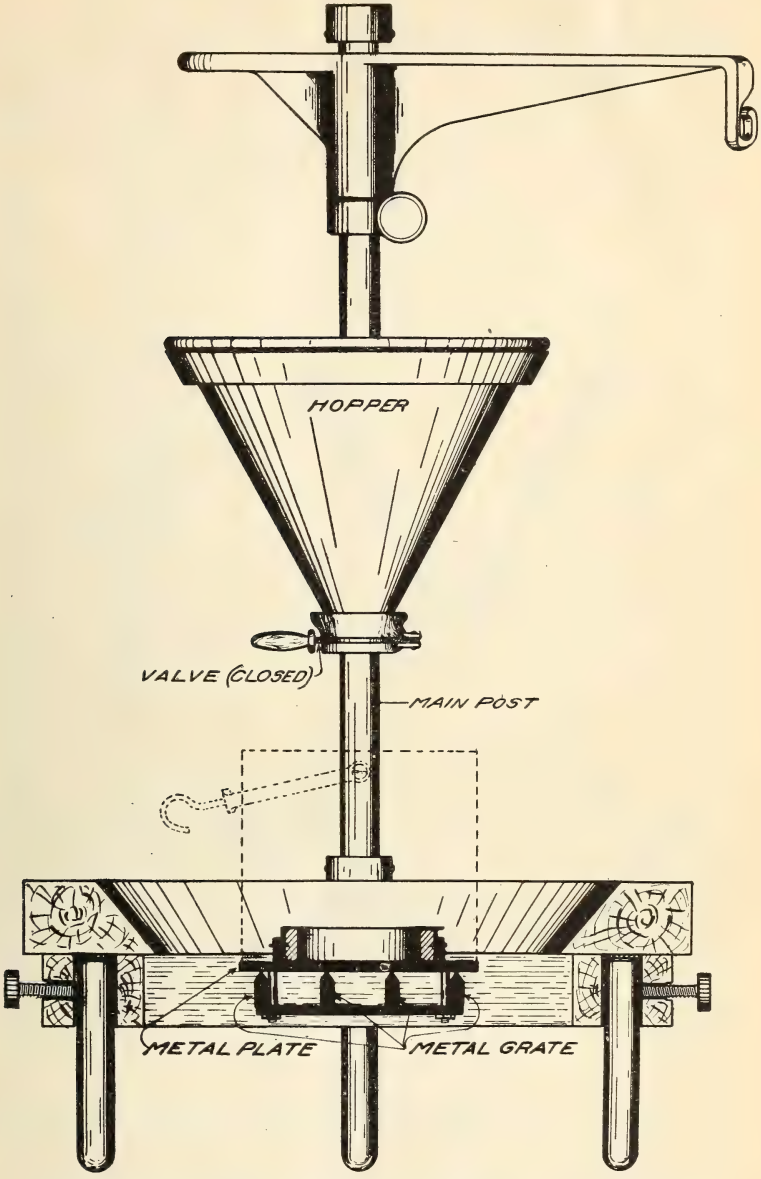

FIG. 6.—Sketch showing how the plate is bolted on the iron grating.

nates in a ring $7\frac{1}{4}$ inches in diameter to hold the hopper, the upper arm terminating in a hook from which the scalebeam can be sus-

pended. The arms are held in place at any given height on the post by means of two metal clamps, as shown in figure 7.

Each of these arms has a projection extending backward past the rear or guide post, so arranged that when the ring of the lower arm and the hook of the upper arm are swung to a position directly over

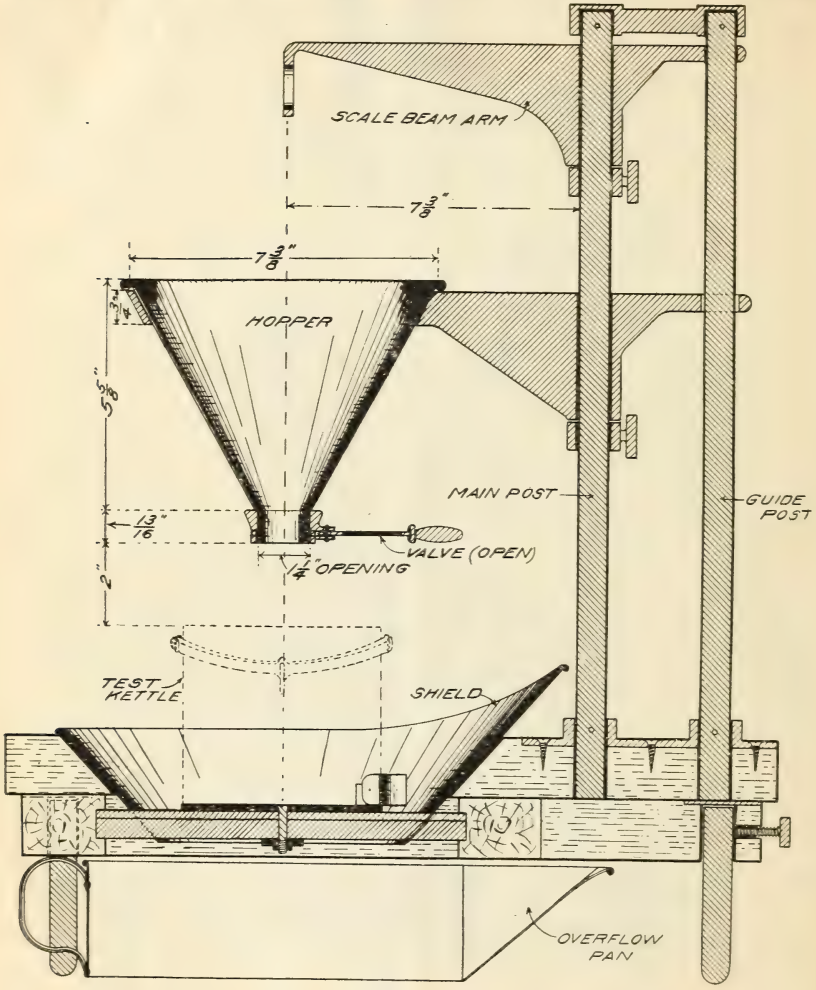

FIG. 7.—Sectional view of the testing apparatus, showing the position of the shield, the grating, and the plate and how the posts and legs are sunk into the framework.

the plate in the base these projections are in contact with the guide post. The projection on the lower arm allows the arm with funnel to swing to the left, while the projection on the upper arm allows this arm with its scalebeam to swing to the right.

The base of the stand rests on three adjustable metal legs which fit into metal sockets sunk into the under side of the base, in the

positions shown in figure 8. The legs are held in place by means of set screws. A pan for catching the overflow from the test kettle is placed underneath the grating.

The hopper, which rests in the ring of the lower arm, is large enough to hold more than a quart of grain and should be of the shape and size shown in figure 7. A valve at its lower opening holds the grain in the hopper until ready to make the test. The opening, or outlet, in the bottom of the hopper is $1\frac{1}{4}$ inches in diameter.

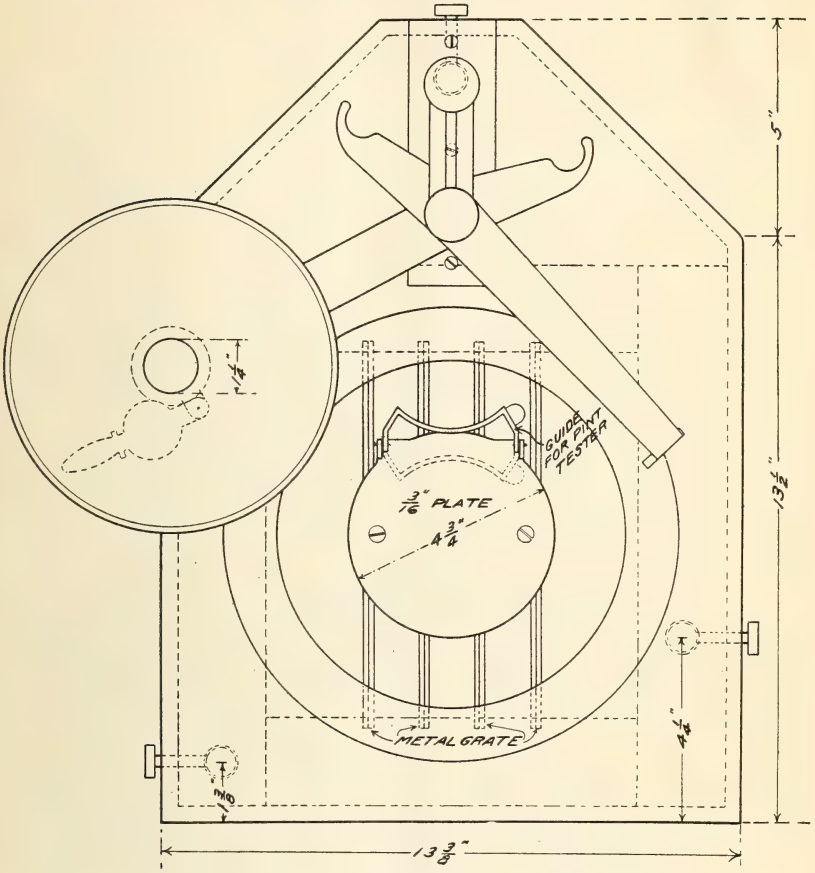

FIG. 8.—Diagrammatic view of the testing apparatus, illustrating the arrangement of the iron grating, the plate, and the guide.

The special stroker is of hard wood, three-eighths of an inch thick, $1\frac{3}{4}$ inches broad, and 12 inches long, each edge being a perfect half circle. This stroker should be used for all tests.

The stand can be used with either the ordinary test kettle and beam or with the test kettle and special combination beam shown in figure 4. The ordinary test kettle and beam, or grain tester, as it is ordinarily called, is well known to the grain trade and needs no

further description. In testing grain for weight per bushel, it is often essential to know the exact weight in fractions of a pound, and this is especially true in the grading of commercial grain, where the rules for the grades specify a minimum test weight which reads in half pounds.

The special beam, graduated to read in tenths of a pound, was devised in order to make it possible to obtain reliable results reading in fractions of a pound. This special beam has two bars, one above the other, each of which has three lines of graduations. The first line on the lower bar reads in pounds per bushel, in divisions of 10 pounds up to 60 pounds; the second line reads in pounds and ounces by one-half ounce divisions up to 2 pounds dead weight, and is used principally for determining "dockage" in grain; the third line reads in percentage of 2 pounds by 1 per cent divisions up to 100 per cent. The first line of graduations on the upper bar reads in pounds and tenths of a pound up to 10 pounds per bushel; the second line reads in grams by 2-gram divisions up to 200 grams dead weight; and the third line reads in percentage of 200 grams by 1 per cent divisions up to 100 per cent. These last two lines of graduations will be found especially useful in the analysis of corn to determine what it should grade from the standpoint of damaged kernels or of foreign matter and finely broken corn.

The poise on the lower bar is supplied with a set screw, so that it can be moved to any one of the 10-pound graduations and clamped in position to keep it from shifting while repeated weighings are being made on the upper beam.

OPERATING THE TESTER.

Place the tester on a solid table top or other firm base. Adjust the height of the funnel arm so that the opening in the bottom of the funnel is exactly 2 inches above the top of the test kettle. Place the test kettle on the metal plate over the grate and see that the overflow pan is in place under the grate opening. Swing the hopper arm into the forward position until the projection extending backward is in contact with the guidepost, when the opening in the bottom of the funnel will be directly over the center of the test kettle. Close the valve in the outlet from the hopper and fill the hopper with the grain or seed to be tested. Open the valve wide with a quick motion and allow the grain to run through until the kettle overflows. Swing the hopper arm out of the way to the left. Strike the excess grain from the top of the test kettle with three zigzag motions of the special stroker, being careful that the sides of the stroker are held in a vertical position and that the kettle is not jarred during the operation. Bring the beam arm with beam suspended into its forward

position. After hooking the test kettle to the short arm of the special scalebeam, the poise on the lower beam must be placed at one of the graduations showing a weight lower than the sample is expected to weigh and the operation is completed by moving the poise on the upper bar to a point necessary to make the beam balance. For instance, wheat usually tests between 50 and 60 pounds per bushel, so that when testing wheat the poise on the lower bar would ordinarily be set at 50 pounds and the weight determined by moving the poise on the upper bar to the necessary position to make the beam balance; if this point should happen to be 7.3 pounds, the test weight of the sample would be 57.3 pounds (50 pounds plus 7.3 pounds).

In testing for weight per bushel of other grains, the poise on the lower bar would ordinarily be set at 30 pounds for oats; at 40 for barley, buckwheat, and rough rice; and at 50 for rye, corn, kafir, milo, feterita, and flaxseed. If the ordinary beam is used instead of the special beam, then the weighing should be done in the usual manner, except that the beam should be suspended from the hook of the upper arm instead of being held by hand. Great care must always be exercised that the beam which is especially adjusted to the particular test kettle with which the test is made be used and that when either the test kettle and ordinary beam or test kettle and special beam are used, the beam must at all times be in balance when the poise or poises, as the case may be, are in zero position.

STANDARD METHOD OF MAKING THE TEST.

The conditions given in the method described below have been found to be most essential in making uniform tests of weight per bushel and obtaining accurate results and have been adopted as standard in connection with Grain Standardization Investigations:

(1) Have an accurate grain tester.
(2) Fill the test kettle from a hopper—
  (*a*) having an opening $1\frac{1}{4}$ inches in diameter at its base,
  (*b*) firmly supported 2 inches above the test kettle.
(3) Have the test kettle rest on a firm base.
(4) Fill the kettle each time with the same amount of overflow.
(5) Strike the excess grain from the top of the overflowing kettle in a uniform manner with three zigzag motions with the sides of the special stroker held vertically, avoiding meanwhile any jarring of the contents.
(6) Make the weighings on a beam accurately graduated to read in fractions of a pound.

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